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JPRS L/8412

20 April 1979

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TRANSLATIONS ON USSR SCIENCE AND TECHNOLOGY
PHYSICAL SCIENCES AND TECHNOLOGY
(FOUO 22/79)

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ELECTRONICS AND ELECTRICAL ENGINEERING

UDC 621.396.962:550.35

MICROWAVE RADIATION OF THE SURFACE OF THE EARTH WHERE VEGETATIVE COVER IS PRESENT

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian No 2, Feb 79 pp 256-264

[Article by K.P. Kirdyashev, A.A. Chukhlantsev and A.M. Shutko, manuscript received 27 Dec 77]

[Text] The results of experimental studies of the spectra of the microwave radiation of the earth's surface where vegetative cover is present are given. The specific features of the microwave radiation inherent in various types of vegetation are established. Quantitative estimates of the influence of vegetation on the radiation of the earth's surface are derived. A relationship is ascertained between the characteristics of the microwave radiation and certain biometric parameters of the vegetation.

The need arises for the derivation of quantitative estimates of the shielding influence of diverse types of vegetative covers, agricultural crops, grasses, undergrowth, trees, etc., in connection with the development of microwave radiometric methods and equipment for the remote display of the state of a subjacent surface: the determination of soil humidity, the degree of bogginess of terrain, its passability, and the localization of centers of forest fires [1-3].

Along with a study of the shielding influence, it is also of interest to study the capability of determining some of the biometric characteristics inherent in the vegetative cover: the biomass, height, etc., based on the data of microwave radiation spectral measurements.

1. Some results of original experimental research in this field, conducted at the Institute of Radioengineering and Electronics of the USSR Academy of Sciences over the period from 1965 to 1976, are presented in this paper. The experiments were conducted at a permanent ground station, from on board aircraft and earth satellites in a broad range of wavelengths from 0.8 to 30 cm (see the table).

The Characteristics of Microwave Radiometric Equipment and the Objects of Study

Serial No. № п.п.	Conditions and time Условия и время проведения экспериментов experiments were performed	Regions where the Районы проведения экспериментов experiments were performed.	Objects of Study Объекты исследования	Equipment Параметры аппаратуры Wavelength длина волны, см cm	Parameters (1) угол наблюдения от надира, град	(2) чувствительность °К при постоянной времени 1 сек	(3) разрешение на местности
1	Стационарные наземные 1968–1970 гг. (A)	Московская обл. Moscow Oblast	травяной покров, березняк (B)	10; 30	30–70	3–5	5–15 м
2	ИЛ-14, 1965–1966 гг. IL-14, 1965-1966	Московская обл., Крымская обл. (C)	степи, леса, заболоченные районы (D)	3	25	0,1	5–100 м
3	ИЛ-14, 1973–1976 гг. IL-14	Московская обл., Крымская обл., Дальний Восток, Владимирская обл., Средняя Азия, Красноярский край (E)	сельскохозяйственные поля, степи, заболоченные районы, леса Agricultural fields steppes, boggy regions, forests	0,8 3,4	60 25	0,5–1,5	5–200 м
4	ИЛ-18, 1974–1976 гг. IL-18			0,8; 1,35; 2,25; 3; 10; 20; 30	30 0	0,3–1,5	20–200 м
5	АН-2, 1976 г. AN-2, 1976	Central Asia Средняя Азия	Agricultural fields сельскохозяйственные поля	18	0	0,3	5–200 м
6	ИСЗ «Космос-243», 1968 г. (F)	Южная Америка, Центральная Африка, Западная Сибирь, Дальний Восток и др. (G)	степи, леса, заболоченные районы steppes, forests, boggy regions	0,8; 1,35; 3,4; 8,5	0	0,7–2,0	30–50 км
7	ИСЗ «Космос-384», 1970 г. (H)						

Key: 1. Observation angle from the nadir, degrees;
2. Sensitivity ° K at a time constant of one second;
3. Terrain resolution;
A. Permanent ground based measurements, 1968-1970;
B. Grass cover, birch groves;
C. Moscow oblast, Crimean oblast;
D. Steppes, forests, boggy regions;
E. Moscow oblast, Crimean oblast, Far East, Vladimirskaya oblast, Central Asia, Krasnoyarsk kray;
F. "Kosmos-243" satellite, 1968;
G. South America, Central Africa, Western Siberia, Far East, etc.;
H. "Kosmos-384" satellite, 1970.

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The values of the brightness temperatures and emissivities were estimated taking into account internal calibration standards, as well as on the basis of the radio brightness gradient of a smooth water surface with a known water temperature, as well as for sections of thick forest. The emissivity of a water surface was determined from the Fresnel formulas, while the emissivity of the calibrating forest sections was taken equal to unity. The error in the measurements of the brightness temperatures amounted to 5--15° K.

Measurements of the microwave radiation of ground covers demonstrated that the influence of vegetation on the radiation of the earth's surface is determined by the type of vegetative cover and its condition. The parameters which determine the radiation level are: the emissivity of the ground surface, the factors of radiation reflection and transmittance by the vegetation, and the degree of coverage of the ground surface by the vegetation. The specific radiation features inherent in different types of vegetative covers arise as a consequence of the differing ratio of the magnitudes of these parameters. Depending on the nature and degree of influence of the vegetation on the radiation of the earth's surface, the following types of vegetative covers can be differentiated: a) agricultural crops in the early stages of vegetation, spike and grass covers; b) "broad leaf" agricultrual crops (sunflowers, corn, beets, etc.); c) underbrush and forest vegetation.

Characteristic radiation spectra are presented in the paper as applied to these types of vegetative covers and the corresponding attenuation levels are evaluated. Examples of the recordings of the brightness temperatures T_B of the ground surface are shown in Figure 1, which are characteristic for the indicated types of vegetation. The spectral curves of the emissivity $\kappa(\lambda)$ of the discriminated areas are shown in Figure 2.

The data of the measurements, which are shown in Figure 1a, were obtained from experimental fields of the Yenisey hydrological station by means of the radiometric complex installed on-board an IL-18 aircraft. A comparison of the radiation spectra for a field of winter rye with a height of 20-25 cm and plowed ground with a value of soil moisture close to that of the rye (based on data of ground observations, the soil humidity for both fields amounted to 27--30%) shows that the influence of this type of vegetation is substantial in the centimeter band (Figure 2a). The noted increments in the level of the emissivity due to the influence of vegetation amount to 0.05--0.15. In the decimeter band, the radiation of areas with vegetation differs little from the radiation of the open soil. An analysis of the radiation spectra of grass vegetation, covering a pasture (Figure 1a), forest glades and cut over areas (Figure 1c), as well as the boggy regions of the ground surface (Figure 1d), shows that the influence of grassy vegetation is likewise manifest primarily in the centimeter region of the spectrum and little at decimeter wavelengths.

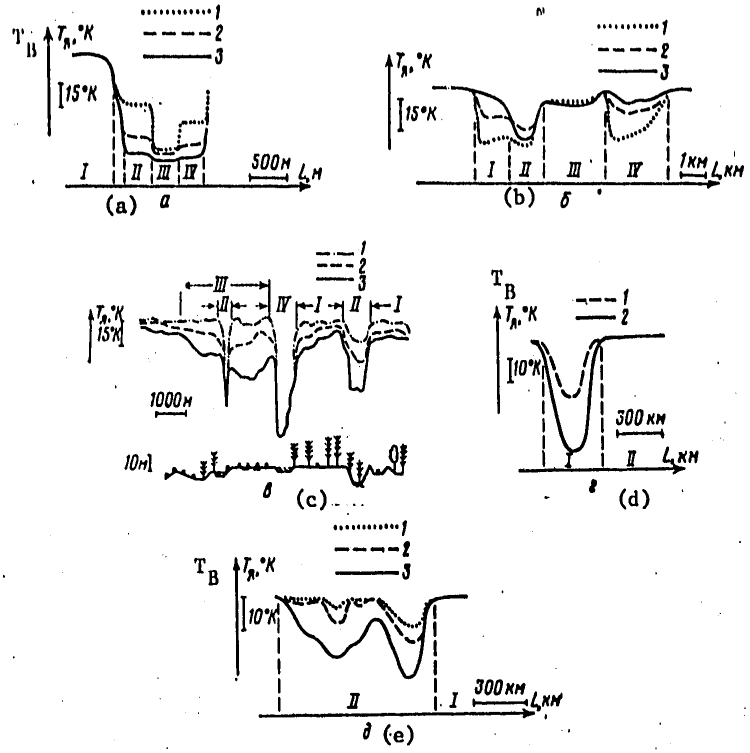

Figure 1. Examples of the recordings of the brightness temperatures of the earth's surface where vegetation is present:
a. Area of mixed forest (I), winter rye (II), plowed land (III) and pasture (IV) at wavelengths of 2.25 cm (1), 10 cm (2) and 30 cm (3);
b. Corn fields with dry (I) and moist (II) soil, dry pasture (III) and sunflower fields on dry soil (IV) at wavelengths of 3.4 cm (1) 10 cm (2) and 30 cm (3);
c. Forested terrain in the Krasnoyarsk kray, including coniferous and mixed forest (1), flooded regions (II) [sic], boggy areas (III) and a lake (IV), at wavelengths of 2.25 cm, (1), 10 cm (2) and 30 cm (3).
d. The boggy Bol'shoy Khingan region in the Far East (I) and Siberian forest (II) at wavelengths of 3.4 cm (1) and 8.5 cm (2);
e. The Sahara Desert (I) and the boggy region of the Upper Nile (II) at wavelengths of 1.35 cm (1), 3.4 cm (2) and 8.5 cm (3).

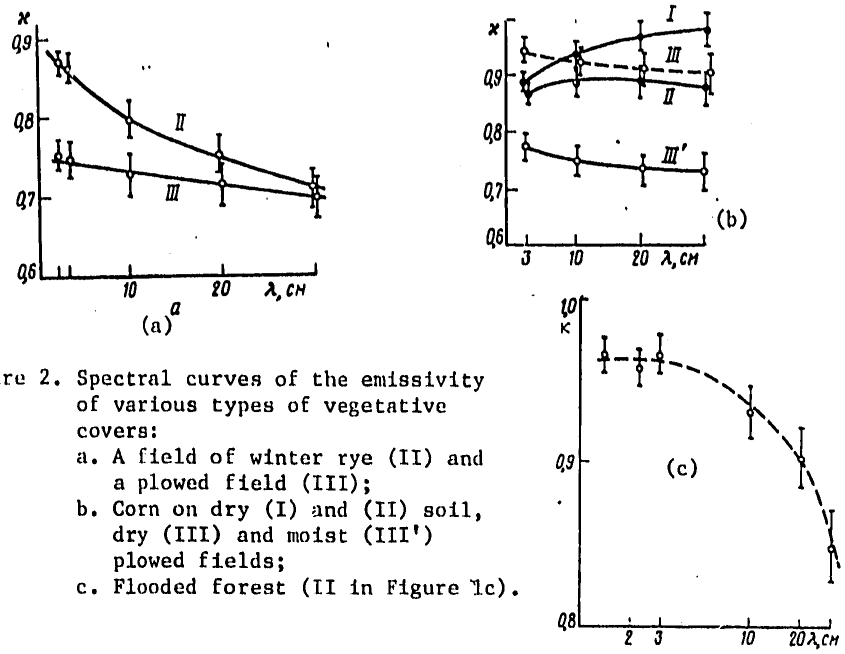

Figure 2. Spectral curves of the emissivity of various types of vegetative covers:
a. A field of winter rye (II) and a plowed field (III);
b. Corn on dry (I) and (II) soil, dry (III) and moist (III') plowed fields;
c. Flooded forest (II in Figure 1c).

A study of the radiation spectra of broad leaf crops was carried on the irrigated fields of the Crimean oblast (Figure 1b). A distinctive feature of the radiation spectra of such crops is the reduction in the emissivity level with a shortening of the wavelength. A change in soil humidity has practically no effect on the emissivity of a cornfield in the centimeter region of the spectrum and exerts a marked influence in the decimeter region (Figure 2b). This fact indicates the complete shielding of the soil radiation by the vegetation in the centimeter band (the height of the corn is 1.5--2 m). A lower value of the emissivity of a cornfield with dry soil for short wavelengths, as compared to longer wavelengths, can be explained by the increasing influence of the reflective properties of broad leaf vegetation with the shortening of the electromagnetic wavelength.

An investigation of the radiative characteristics of forest showed that thick forest masses on dry soil are characterized by the greatest emissivity, which is close to unity in the frequency range studied. An idea of the shielding properties of forest vegetation can be obtained from a consideration of the radiation spectra of a flooded pine forest (Figures 1c and 2c). Based on the data of ground observations and aerial photographs, the underlying surface under the trees was flooded with water in the amount of 60--80%. As follows from Figure 2c, in the centimeter band, the emissivity is close to unity, something which indicates the complete shielding of the radiation of the underlying surface by the forest canopy. The observed spectral dependence

of the radiation intensity in the decimeter band attests to the "semitransparency" of the canopy for decimeter wavelengths. The spectral features noted here for the radiation of forest regions, which are characterized by a high level of moisture in the subjacent surface, were observed when recording the microwave radiation of the earth from the "Kosmos-243" and "Kosmos-384" satellites (Figure 1e).

A comparison of the radiation spectra of a ground surface with grass and forest vegetation shows that these two types of covers have spectral curves for the emissivity which are close, and are characterized by a monotonic reduction in the emissivity with an increase in wavelength. A substantial difference between these types of vegetation consists in the extent of the shielding influence, which is considerably greater for forest vegetation. This is clearly manifest in the analysis of the radiation spectra of boggy areas with an emissivity of the subjacent surface close to the emissivity of water (Figure 1c, d, e). Such studies show that the forest cover completely shields the radiation of the subjacent surface at centimeter wavelengths and leads to an increase in the emissivity of the "forest--water surface" system in the decimeter range up to 0.8--0.9. Grass cover proves to be semitransparent throughout the entire range of frequencies which were studied (the increases in the emissivity amount to 0.1--0.4).

2. Based on the data of the experimental studies which were carried out, quantitative estimates were obtained for the levels of attenuation of the microwave radiation for the indicated types of vegetative covers.

The characteristics of the attenuation in a layer of vegetation of the winter rye type were determined from a comparison of the emissivity of areas with vegetation and the emissivity of plowed ground with close values of soil moisture content (Figure 2a). The integral attenuation of the radiations τ can be expressed in terms of the emissivity of an area with vegetation κ and plowed ground $\kappa_п$, neglecting reflection from the vegetation:

$$\tau = \frac{1}{2} \ln \frac{1-\kappa_п}{1-\kappa} \quad (1)$$

where $\kappa = 1 - Re^{-2\tau}$; $\kappa_п = 1 - R$; R is the factor for radiation reflection from the soil. The integral attenuation in winter rye, obtained from measurement data, amounts to 0.05--0.3 nepers (Figure 3) (estimates of the error in the determination of τ due to the difference in temperature and moisture content of the fields studied in the given experiment show that the size of the error does not exceed 0.05 neper).

To interpret the results of measuring the emissivity of broad leaf crops (Figure 2b), it is necessary to account for the effects of reflection from the vegetation. In this case, the emissivity of the cover should be considered in the form [2]:

$$\varkappa=\varkappa_0+(1-R)q_*+Rq_*\varkappa_0,$$

(2)

$$q_*=\frac{q}{1-rR},\quad \varkappa_0=1-q-r,$$

where κ_0 is the emissivity of the vegetation layer; q and r are the transmittance and reflection factors for the vegetation radiation. The parameters q and r for broad leaf crops, in particular, for corn, can be found from a comparison of the emissivities for a corn field and plowed areas having close values of soil moisture content (Figure 2b):

(3)

$$r=\frac{R_2(1-\varkappa_1)-R_1(1-\varkappa_2)}{R_2(1-\varkappa_1R_1)-R_1(1-\varkappa_2R_2)}$$

(4)

$$q=\left[\frac{(\varkappa_1-\varkappa_2)(1-R_1r)(1-R_2r)}{R_1-R_2}\right]^{1/2}$$

where κ_1 and κ_2 are the measured values of the emissivity of the corn field with dry and with moist soils; R_1 and R_2 are the radiation reflection factors from dry and moist soil, defined in terms of the measured values of the emissivity of ploed ground $\kappa_{п1,2} = 1 - R_{1,2}$. Based on the measurement data, the size of the reflection factor does not exceed 0.1, while the transmittance factor varies within limits of 0.3--0.8 (Figure 4).

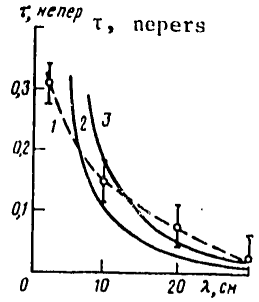

Figure 3. The spectral curve of the integral attenuation of the radiation by winter rye based on experimental data (1) for area II in Figure 1a, and that calculated for values of Qm = 40 quintals/hectare (2) and Qm = 70 quintals/hectare (3), where Q is the biomass and m is the moisture content by weight.

Based on the radiation spectrum of flooded forests (Figure 2c), it proves to be possible to determine the integral attenuation in the canopy. The difference between the emissivity and unity in the centimeter band is determined by the presence of "gaps" in the vegetation. The emissivity of the cover where gaps are present in the vegetation can be expressed as [2]:

(5)

$$\varkappa=1-Re^{-2\tau}-R\xi(1-e^{-\tau})(\xi-\xi e^{-\tau}+2e^{-\tau}),$$

where ξ is the relative area of the gaps. In the case of considerable absorption, $\tau >> 1$, the difference between the emissivity and unity is determined by the quantity $R\xi^2$. To estimate R, it is convenient to consider the graphical function: $\ln(1 - \kappa)$ as a function of $1/\lambda$, where λ is the wavelength. Based on the

obtained values of R ≈ 0.3 and ξ ≈ 0.35, values of the integral attenuation in the canopy for decimeter wavelengths were determined from (5), where these values varied within a range of 0.5--1.5 nepers (Figure 5). It should be noted that the quantity ξ, taken as a constant in the calculations, generally speaking depends on the radiation wavelength because of the fact that for wavelengths comparable with the geometric dimensions of the gaps, diffraction effects appear. Establishing the relationship of the radiative characteristics to the degree of coverage of the earth's surface by vegetation requires further research.

3. We shall consider the relationship between the quantities obtained for the attenuation and the biometric parameters of the vegetation, and in this case, we shall work from the expression derived in paper [3] for the integral radiation attenuation in a vegetation layer with elements in the form of small disks and cylinders:

$$\tau \simeq \frac{u}{3} kNVG\varepsilon_{\text{в}}'' h \sec\vartheta, \tag{6}$$

where $u = 1$ and $u = 2$ for cylinders and disks respectively; $k = 2\pi/\lambda$ is the wave number; V and N are the volume of a vegetation element and the number of them per unit volume; G is the volumetric moisture content of an element of vegetation; $\varepsilon_{\text{в}}''$ is the imaginary part of the complex dielectric permittivity of water; h is the height of the vegetative cover; and θ is the viewing angle.

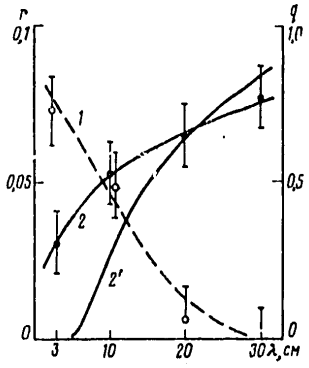

Figure 4. The spectral dependence of the reflection factor (1) and the transmittance factor (2 and 2') for corn.

1, 2: Based on experimental data (areas I and II in Figure 1b);
2': Calculation results for values of Qm = 600 quintal/hectare.

Expression (6) can be reduced to the form:

$$\tau = \frac{2\pi u \sec\vartheta}{3\lambda[\text{м}]} \cdot 10^{-3} Q[\text{кг/га}] m\varepsilon_{\text{в}}'', \tag{7}$$

which relates the attenuation to the biometric parameters of the vegetation: the biomass Q (equal to the mass of vegetation referenced per unit of area) and the moisture content by weight m, defined by the ratio of the weight of water contained in the vegetation to the weight of the dry vegetation. Experimental values of the attenuation in the types of vegetation which were studied are compared in Figures 3--5 with the calculated values, computed in accordance with expression (7) for the model of cylinders (the transmittance factors q (Figure 4) are compared with the calculated values $q = e^{-\tau}$). The quantities for the

biomass and moisture content used in the calculations were taken from ground observation data.

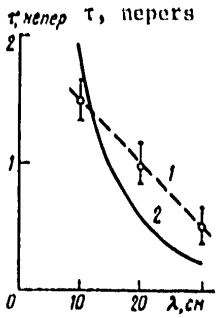

Figure 5. The spectral dependence of the integral attenuation of radiation by a forest canopy, based on experimental data (1) for area II in Figure 1c, and that calculated for a value of Qm = = 700 quintal/hectare (2).

As follows from Figure 3--5, the calculated values satisfactorily agree with the experimental ones. The observed differences can be explained by the approximate nature of the model assumptions which were adopted as regards the shape and nature of the spatial distribution of the elements of the vegetative cover. In the general case, when interpreting the data of radiophysical measurements, it is likewise necessary to take into account the relationship between the fractions of the biomass included in the quasichaotic portion (leaves) and in the oriented elements (stems, trunks) of the vegetative cover. The contribution of these components depends on the angular coordinates of the sounding direction.

Expression (7) can be employed for estimate calculations of the radiation attenuation in vegetative covers.

Based on the values obtained for the attenuation, the influence of vegetation on the radiation of the cover was quantitatively determined. This influence is characterized by the quantity β:

$$\beta = \frac{\Delta \varkappa}{\Delta R} = \frac{q^2}{(1-rR_1)(1-rR_2)}, \tag{8}$$

expressed as the ratio of the change in the emissivity of the cover Δκ to the change in the reflective properites of the surface ΔR. When measuring the moisture content of soils by microwave radiometry [4], β has the meaning of the coefficient for the reduction in the slope of the radiation-moisture content curve $\Delta T_B = \beta f(\Delta W)$, where W is the soil moisture content. Values of β for the types of vegetation studied are shown in Figure 6 and vary in the centimeter band within a range of 0--0.6, and in the decimeter band, within a range of 0.3--1.0.

The dependence of the shielding influence as function of the state of the vegetation in various stages of growth should also be noted. The indicated curves were derived for the case where the microwave radiation of cotton fields in Central Asia were studied. The measurements were performed from on-board an AN-2 aircraft at a wavelength of 18 cm. A comparison of the

emissivity of a cotton field with a plowed area, close in terms of soil moisture content, shows that in step with the growth of the cotton plants, their shielding influence increases (Figure 7). When the cotton height increases from 40 cm up to 1 m, the size of β changed from 0.9 to 0.75.

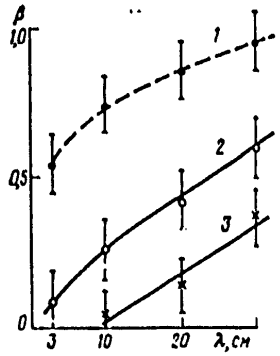

Figure 6. The spectral dependence of the coefficient for the reduction in the slope of the radiation-moisture content curve where a winter rye type of vegetative cover is present (1) as well as for corn (2) and forest (3).

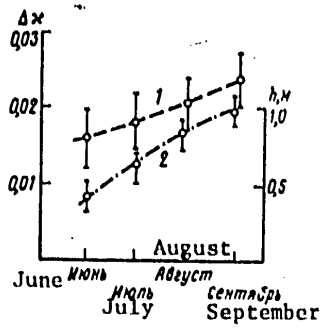

Figure 7. The increase in emissivity of a cotton field above the radiation of plowed ground (1) and the cotton plant height (2) during the experiment.

Conclusions. 1. The experimental studies which were performed ascertained the specific features in the microwave radiation spectra of ground cover, which are inherent in the specific types and states of the vegetation.

2. A comparison of the experimental data with the results of the model calculations, which take into account the biometric and electrophysical indicators of the corresponding types of vegetation, allowed for the derivation of quantitative estimates of the attenuation and reflection of electromagnetic waves by the vegetation in a range of 0.8--30 cm.

3. Quantitative estimates were derived for the shielding effect of the vegetation on the radiation spectrum of the subjacent surface, in particular, the values of the coefficients for the reduction in the slope of the radiation-moisture content curve were determined.

4. The presence of a correlation was ascertained between the characteristics of the microwave radiation and the biometric indicators of the vegetation (biomass, height, moisture content), something which indicates the basic capability of obtaining certain estimates of biometric indicators from the results of radiometric measurements.

The authors would like to express their gratitude to A.Ye. Basharinov for his constant interest in this work and the discussion of the results.

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SCIENTISTS AND SCIENTIFIC ORGANIZATIONS

JOINT MEETING OF SECTIONS OF SCIENTIFIC COUNCILS OF THE STATE COMMITTEE ON SCIENCE AND TECHNOLOGY AND USSR ACADEMY OF SCIENCES

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian, V 36 No 2, Feb 79, pp 372-373

[Article by V. P. Trofimov and K. S. Adzerikho]

[Text] A joint session of the section "Heat Exchange by Radiation" of the Scientific Council on the problem "Mass Transfer and Heat Transfer in Technological Processes" of the State Committee of the Council of Ministers USSR on Science and Technology and the heat and mass exchange section of the Scientific Council on the "Complex Problem 'Thermal Physics' of the AS USSR" was held 6-7 April 1978 in Minsk.

Two of the problems discussed were:

1. Present state of the problem and basic trends of development of methods of mathematical modelling of radiation and complex heat exchange in technological processes.

2. Proposals of the commission on development of a mathematical model of a forest fire.

R. I. Soloukhin, Chairman of the Council of Directors of ITMO [Institute of Heat and Mass Exchange] imeni A. V. Lykov of the AS BSSR, Corresponding Member of the AS USSR opened the conference. Corresponding Member of the AS USSR B. S. Petukhov and Doctor of Technical Sciences A. G. Blokh, chairmen of the sections indicated above conducted the work of the conference.

Problem addresses on the first problem described the contemporary state and means of further development of methods of mathematical modelling of heat exchange by radiation in the real spectrum (V. G. Sevast'yanenko), mathematical methods of solving problems of radiative-conduction heat exchange (A. A. Kobyshev) and methods of mathematical modelling of radiation heat exchange in metallurgical heat engineering (A. S. Nevskiy, V. G. Lisiyenko).

Several speakers discussed mathematical modelling of optical characteristics of molecular gases (V. G. Sevast'yanenko, R. I. Soloukhin and I. F. Goloviyev) and methods of calculation of their radiation based on modelling of the spectral composition (Yu. V. Khodyko). There was considerable interest in a report concerning mathematical modelling of complex heat exchange with consideration of the spectrum of products of combustion, scattering and reflection of flows for a plane layer in which a selectively absorbing, radiating and scattering medium is moving (S. P. Detkov and O. A. Khalevich).

For solution of a problem of hypersonic flow around a blunt body by a radiating gas in the presence of intense vaporization of the frontal surface there was used a gas dynamic model of flow of a non-viscous gas with consideration of its optical characteristics in the shock wave and products of evaporation (V. I. Mirskiy and V. I. Stulov).

One report (I. R. Mikk) presents methods of measurement and processing of experimental data in studies of complex heat exchange.

There were presented results of studies conducted by a collective of authors (K. S. Adzerikho, V. I. Nekrasov, V. P. Trofimov and others) on modelling problems of radiant heat exchange in media of plane geometry and an algorithm of calculation of spectroscopic characteristics for a finite cylinder.

Mathematical modelling of radiation properties of surfaces and their use in calculations of heat exchange by radiation, including radiation with consideration of anisotropy, was the subject of several reports (L. N. Ryzhkov, S. P. Rusin, V. D. Dmitriyev, S. G. Arababov and others) which produced great interest among conference participants.

The reported results of application of mathematical modelling of radiation and complex heat exchange in electric circuits (Yu. M. Ageyev and others) were considered to be quite important. These speakers emphasized the prospects of use of electromodelling for these purposes on the basis of modern electrical engineering devices and computer technology.

A theoretical study (Yu. A. Surinov, L. B. Ionomareva) described the use of a third form of the generalized zonal method for the most general statement of a problem concerning radiant heat exchange in a rectangular multizonal chamber of random length, filled by a heterogeneous absorbing and scattering medium.

More precise definition of individual parameters of the zonal method of calculation of radiation of triatomic gases and coke particles based on generalization of experimental data permitted recommendations for calculating heat exchange by radiation in furnaces of boiler units (V. V. Vitor, I. I. Kopopel'ko and L. V. Latysheva).

There were reports concerning analytical and numerical methods of calculation of radiation conduction heat exchange as applied to elements of electro-vacuum

devices, the use of which permits rather rapid production of necessary information concerning their thermal state (V. S. Koshelev, G. M. Tsymbalov and V. I. Shevstov).

Decrees adopted by the section emphasized the urgency and great importance of further development of physical and mathematical bases of modelling processes of radiation and complex heat exchange, analytical methods of the theory of radiation heat exchange, mathematical modelling of optical characteristics of gas media and radiation properties of construction materials of surfaces of assemblies and also development of studies in mathematical modelling of radiation and complex heat exchange in respect to specific technological processes and industrial apparatus (metallurgy furnaces, tubular furnaces of the petrochemical industry, combustion fireboxes of steam generators and others). There was recognized the benefit of beginning standardized methods of heat design for basic types of some assemblies (including metallurgical furnaces).

There is noted the necessity of further development of zonal methods of calculation of heat exchange by radiation in metallurgical furnaces, tubular furnaces of the petrochemical industry, fireboxes of heat engineering assemblies and others with consideration of combustion processes.

At some sections, it was noted that an important problem for development of mathematical models of radiation and complex heat exchange is their coordination with real technological processes.

Doctor of Physical and Mathematical Sciences A. M. Grishin discussed, in relation to the second problem, a conference involving a temporary committee on development of a mathematical model of a forest fire.

Presently existing models of forest fires describe either individual forms of fires or individual aspects of this phenomenon without considering the entire complex of the processes occurring which have a significant effect on it.

As a result of discussion of preliminary materials, there was proposed a physical and mathematical model, developed on the basis of the mechanics of the reacting media. A positive distinction between it and other models is that, in it, there are taken into consideration basic physical and chemical processes, arising during forest fires and its mathematical description involves the laws of conservation of energy, momentum and mass. The model proposed considers the effect of atmospheric processes, the type of forest vegetation, structure and types of combustible materials and the topographical characteristics of the locality.

Approving the work of the temporary committee, the sections approved the proposals of the committee for mathematical modelling of a forest fire.

A continuation of work on improvement of data and the creation of particular models for the purpose of practical application of them for development of methods and means of extinguishing forest fires was recommended.

Organizational measures for practical checking of scientific research in this area were proposed.

The problems discussed created great interest. There were in attendance 77 specialists (including 2 corresponding members of the AS USSR, 21 with Doctor of Science degrees and 41 with Candidate of Science degrees, representing 44 scientific research organizations and colleges of the country. (TsKTI [Central Scientific-Research Design and Construction Institute for Boiler Turbines], ENIN [Power Engineering Institute imeni G. M. Krzhizhanovskiy], IVTAN [USSR Academy of Sciences Institute of High Temperatures], ITMO of the BSSR Academy of Sciences, ITTF AN SSSR, Institute of Philosophy of the BSSR Academy of Sciences, VNIIMT [All-Union Scientific Research Institute of Metallurgy and Heat Technology], MEI[Moscow Power Engineering Institute], etc.).

2791
CSO: 1870

PUBLICATIONS

MAGNETIC FLUIDS--NATURAL CONVECTION AND HEAT EXCHANGE

Minsk MAGNITNYYE ZHIDKOSTI--YESTESTVENNAYA KONVEKTSIYA I TEPLOOBMEN in Russian 1978 signed to press 6 Jul 78 pp 2-4, 205-206

[Annotation, table of contents and introduction from book by P. E. Fertman, Izdatel'stvo "Nauka i Tekhnika," 1,100 copies, 208 pp]

[Text] This book discusses the main methods of synthesizing magnetic fluids and their physical properties. Original results from studies of convective heat exchange in magnetic fluid layers of various configurations located in nonhomogeneous magnetic fields are presented. The rapid development of the thermomechanics of magnetic fluids, at the interface between mechanics and electrodynamics of continua, has been accompanied by extensive incorporation of the new material, magnetic fluid, into industry. The publication of these results will acquaint a wide range of specialists with the properties of magnetic fluids and may expand their use.

The book is intended for scientific personnel and engineers dealing with thermophysics, fluid mechanics and heat engineering, and may be used by college students.

Tables, 3; illustrations, 51; bibliography, 187 items.

Contents Page

Foreword

The development of modern engineering has been accompanied by the search for and development of new working media which make possible effective use of power production equipment and the development of original industrial processes and equipment designs. On the other hand, scientific research in energy (heat) and mass transport has been aimed at establishing interconnections between relatively independent processes. This tendency was noted by A. V. Lykov in the early 60's. In particular, the study of the interaction between electromagnetic fields and fluid and gaseous media has been especially fruitful.

In the last decade, the attention of a wide range of investigators has been drawn to a new industrial material, the magnetic fluid, whose interaction with an external magnetic field is governed by its powerful magnetic properties. The study of this interaction is the province of what is called "ferrohydrodynamics". It expands the traditional range of magnetohydrodynamics and is located at the interface between continuum mechanics and electrodynamics.

In view of the interrelationship between the temperature conditions of a medium and the electrodynamic interaction between the magnetic fluid and a field, we

have related the questions discussed in this book to the thermomechanics of magnetic fluids. Primary attention has been devoted to identifying the nature of convective heat exchange in magnetic fluids, but at the same time much information on the physical properties of these fluids has been presented and an attempt has been made to systematize theoretical models.

Naturally, in an introductory work such as this many important questions have been left out of the discussion. But the author hopes that the book will help the reader to form a rather complete conception of the development of this relatively problem in fluid dynamics.

Materials prepared by V. K. Rakhuba and N. P. Matusevich were used in the preparation of section 1.2, materials prepared by V. G. Bashtov and I. Pavlinova in section 3.2, materials by A. M. Vislovich in Appendix 1, and materials by V. K. Polevikov in Appendix 2. B. E. Mashevskiy took part in the writing of Chapter 2.

The author expresses his gratitude to all the above comrades for their work.

The author is deeply grateful to Dr. of Physical and Mathematical Sciences B. M. Berkovskiy, who proposed the idea of writing this book, for his constant interest and scientific assistance.

8480
CSO: 1870

PUBLICATIONS

AUTOMATING THE DESIGN OF COMPLEX LOGIC STRUCTURES

Moscow AVTOMATIZATSIYA PROYEKTIROVANIYA SLOZHNYKH LOGICHESKIKH STRUKTUR in Russian 1978 signed to press 10 Oct 78, pp 2, 351-352

[Annotation and table of contents from book edited by V. A. Gorbatov, Energiya, 352 pages, 7000 copies]

[Text] ANNOTATION

This book is devoted to automating the designing of logic structures from specified integrated modules based on existing programs that automatically take into account the design semantics of realizable transformations. This makes it possible to work out an otpimum strategy for the automated design of high-quality complex logic structures. Realization of such programs is achieved by using the proposed software, namely, the system for interpreting Boolean logic (SIBUL). Examples are given for implementing logic structures using multifunctional adaptive modules used in industrial automation.

The book will be useful to specialists who are working on automating the design of numerical control systems, as well as for graduates and students of the appropriate specialties.

CONTENTS

6948
CSO: 1870

PUBLICATIONS

ARITHMETIC UNITS OF DIGITAL COMPUTERS

Moscow ARIFMETICHESKIYE USTROYSTVA EVM in Russian 1978, signed to press 23 Aug 78, pp 1-4, 177

[Annotation, introduction, and table of contents from book by G. N. Solov'yev, Energiya, 15,000 copies, 177 pages]

[Text]

ANNOTATION

This book explores problems of designing arithmetic units used in existing and newly designed digital computers. Number systems and means for representing numbers are presented, with a great deal of attention paid to the methods of implementing arithmetic operations using both fixed- and floating-point arithmetic. Design questions are treated in the book by presenting information on registers, summers, arithmetic unit circuits of various types, methods for controlling transmissions, arithmetic and logic transforms, and so forth.

The book is intended for a wide circle of specialists occupied with questions of designing and applying digital computers, as well as for students in the fields of design and application of digital computers.

INTRODUCTION

Of all tasks related to the theory and design of digital computers during the 30 years of their existence, the established and most stable have been the foundations of theory and design of devices that implement the arithmetic and logic transformations of binary information.

The present publication is devoted to this topic. The book reflects an attempt to present that material which has been filtered out by the 30-year period of existence of digital computers. Accordingly, the entire content of the book is oriented exclusively to the binary system of numbers and in discussing the theoretical foundations only those methods are considered that have found use in digital computers of the second and third generation and about which there is no doubt as to their use continuing into future generations as well. Such an approach is characteristic for both circuit and system design questions considered in this book.

The entire content of the book represents the results of the desire of the author to present material from general points of view without extraneous details, particularly in circuits of the devices considered, and not from the point of view of a specific digital computer.

In choosing material, the author has attempted to give an integrated presentation on questions related to the topic under consideration. Within the framework of a single publication and along with the traditional arithmetic foundations, the registers and summers, and the methods of increasing the speed of performing operations of multiplication and division, the following are considered:
The foundations underlying the operation of arithmetic units in a parallel, sequential, and sequential-parallel operation for numbers with fixed- and floating-point representation;
Control of the operation of the arithmetic units, where the main attention is turned to the direct and continuous control of problems, arithmetic and logic transformations, modulo 2;
Dynamic storage and shift registers;
The foundations of representation, arithmetic operations on numbers in the binary-decimal system of numbers, basic questions of implementing tabular arithmetic, rounding the results of arithmetic operations on numbers with fixed- and floating-point representation, and a number of other specific questions of arithmetic foundations that find broad application in digital computers of the third generation.

All the material in the book, particularly Chapter 4, is designed for use of integrated circuits. Basic questions of integrated circuit technology illuminated in Chapters 1 and 3, in which the logical foundations are given in terms of volume necessary for the formal description of algorithms for arithmetic and logical transformation as well as circuits for the basic components of arithmetic units, free the reader from the need to turn to specialized literature in studying and becoming familiar with the present book.

Obviously, a book that reflects such complex questions is quite limited in scope and necessarily has to be short and laconic in the presentation of a number of topics. The reader has to judge as to what extent it has been possible to achieve the above-presented ideas.

In the author's opinion, the present book will be useful for students in the specialty of electronic computers as well as for specialists working in the field of computing technology.

The author would like to express his gratitude to the instructors of the electronic computer faculty of the Moscow engineering physics institute, whose practical comments have led to the formulation of the present book and to his colleagues on the faculty for the great help in preparing the manuscript for publication.

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CSO: 1870

PUBLICATIONS

DESIGN OF FUNCTIONAL SUBASSEMBLIES FOR DIGITAL COMPUTERS USING INTEGRATED CIRCUITS

Moscow KONSTRUIROVANIYE FUNKTSIONAL'NYKH UZLOV EVM NA INTEGRAL'NYKH SKHEMAKH (Design of Functional Subassemblies for Digital Computers Using Integrated Circuits) in Russian 1978 signed to press 28 Feb 78, pp 2, 199-200

[Title, annotation, and table of contents from book by B. I. Yermolayev et al., Sovetskoy Radio, 22,300 copies, 200 pages]

[Text] Methods are presented for designing the basic functional subassembly of a digital computer, the plug-in module, that contains discrete elements, integrated circuits, printed circuit boards, and connectors.

The book is intended for a wide circle of specialists working in the field of computer design.

CONTENTS

6948
CSO: 1870

PUBLICATIONS

UDC 539.107.4

DETECTION OF IONIZING RADIATION

Moscow DETEKTORY IMPUL'SNOGO IONIZIRUYUSHCHEGO IZLUCHENIYA (Detectors of Pulsed Ionized Radiation) in Russian 1978 signed to press 22 Dec 77 pp 2-4, 172-173

/Annotation, table of contents and introduction from book by Ziyat Adbullovich Al'bikov, Aleksandr Ivanovich Veretennikov, Oleg Vasil'yevich Kozlov, Atomizdat, 1,980 copies, 176 pages/

/Text/ The measurement of pulsed ionizing radiation is an urgent problem of experimental physics and radiation technology. It is neceesary to make such measurements when developing and using pulsed X-ray equipment and particle accelerators, in thermonuclear research, medicine and other fields of science and technology.

Detectors designed to measure pulsed ionizing radiation are examined in the book. The principles of their construction are set forth and estimated and experimental data on the characteristics of the detectors are cited.

The amplitude, time and spectral characteristics of detectors of various types, as well as the limitations connected with statistical fluctuations of output currents are examined. The main attention is devoted to detectors with nanosecond and subnanosecond resolution.

The book is intended for experimental physicists and specialists in the field of nuclear instrument making.

65 figures, 21 tables 244 references.

Contents Page

Introduction

The measurement of ionizing radiations is of great importance in modern science and technology. With the introduction of the achievements of experimental nuclear physics in industry, medicine and other sectors of the national economy more and more attention is being devoted to the measurement of the parameters of the fields of ionizing radiation, which not only bear information about the operation of the devices which are the sources of radiation, but also present information on the operating conditions in these fields of the objects of observation and service.

A peculiarity of many devices, which are presently being used as sources of ionizing radiation, is the pulsed mode of their operation. The surrounding fields of ionizing radiation in contrast to the fields created by static sources, the average intensity of the radiation of which is constant or changes according to the laws of radioactive decay, are of a pulsed nature in this case.

The detection of ionizing radiation is based on the transformation of the energy of the particles being recorded into an electric signal at the output of the detector, which is subsequently processed by means of radioelectronic equipment. According to the type of output signals the detectors of ionizing radiations are divided into discrete detectors, at the output of which a sequence of electric signals (pulses) is formed from the individual particles, and analog detectors, at the output of which the signals from individual particles are not differentiated, while the information on the recorded radiation is obtained according to the value of the electric current in the output curcuit of the detector.*

In the measurement of the parameters of pulsed sources and fields of ionizing radiation the form of the pulses of radiation, their amplitude (maximum intensity), the intervals between the pulses in the case of the

*This division of the detectors is arbitrary, since as the intensity of the radiation increases and the number of recorded particles correspondingly decreases, the analog detector shifts to the discrete mode of operation.

emission of a series (or train) of pulses and the form of the individual pulses in the series are of great interest.

Analog detectors are usually used for the measurement of the indicated parameters of pulsed ionizing radiation when using the appropriate radioelectronic equipment, since the use of discrete detectors for these purposes is practically impossible, especially given a nanosecond and, what is more, a picosecond duration of the individual pulses or series of pulses of ionizing radiation.

Discrete detectors of elementary particles, which are designed for recording ionizing radiation of static sources, have been described in many monographs.* At the same time the authors do not know of any works, in which the questions of the theory and use of detectors of pulsed ionizing radiation were systematized. An attempt is made in the book to set forth the main questions of theory and the practical results obtained in the area of the development and use of analog detectors of pulsed ionizing radiation; here the main attention is devoted to the analysis of the possibilities of using these detectors for measuring pulses of radiation in the nanosecond and subnanosecond ranges of activity.

In setting forth the materials the authors were guided, where possible, by the All-Union State Standards issued in the USSR in recent years. However, this was not always possible. The greatest difficulties arose in the area of terminology, and this is natural in connection with the novelty of the question being covered. In describing the characteristics of the detectors new definitions were introduced, which, in the opinion of the authors, are practically necessary, logically stem from the principles of operation of the detectors and ensure the metrological nature of the measurement of the parameters of radiations. In this case analogous terms from other fields of metrology were used.

The authors did not set as a goal of the book the description of the methods and equipment for measuring the parameters of pulsed radiation--this is unquestionably of independent interest to broad groups of readers. However,

*V. Veksler, L. Groshev, B. Isayev, "Ionizatsionnyye metody issledovaniya izlucheniy" /Ionization Methods of Studying Radiations/, Moscow-Leningrad, Gostekhteorizdat, 1950; B. Rossi, H. Staub, "Ionizatsionnyye kamery i schetchiki" /Ionization Chambers and Counters/, Moscow, Izdatel'stvo inostrannoy literatury, 1951; V. Price, "Registratsiya yadernogo izlucheniya" /Recording of Nuclear Radiation/, Moscow, Izdatel'stvo inostrannoy literatury, Moscow, 1960; V. I. Kalashnikov, M. S. Kozodayev, "Detektory elementarnykh chastits" /Detectors of Elementary Particles/, Moscow, "Nauka", 1966; V. V. Matveyev, B. I. Khazanov, "Pribory dlya izmereniya ioniziruyushchikh izlucheniy" /Instruments for Measuring Ionizing Radiations/, Moscow, Atomizdat, 1972; L. S. Gorn, B. I. Khazanov, "Izbiratel'nyye radiometry" /Selective Radiometers/, Moscow, Atomizdat, 1975, and others.

in some instances the authors were forced to set them forth in brief, since otherwise some characteristics of the described detectors and the possibilities of their practical use would have remained unsubstantiated.

The Introduction and Chapters 1 and 9 were written by A. I. Veretennikov; Chapters 2, 3, 4, 5 and 8 by O. V. Kozlov; Chapters 6, 7 and 10 by Z. A. Al'bikov. The authors are grateful to V. A. Novikov, S. A. Kuchay, Yu. A. Brusov, L. Z. Nazarova and L. M. Shishlyakova for useful remarks and assistance in the work on the book.

7807
CSO: 1870

PUBLICATIONS

539.125.5.17

NEUTRON METHODS OF ANALYZING THE COMPOSITION OF MATTER

Moscow NEYTRONNYYE METODY NEPRERYVNOGO ANALIZA SOSTAVA VESHCHESTVA (Neutron Methods of the Continuous Analysis of the Composition of Matter) in Russian 1978 signed to press 28 Sep 77 pp 2-5, 159

/Annotation, table of contents and introduction from book by Yevgeniy Rostislavovich Kartashev and Aleksandr Sergeyevich Shtan', Atomizdat, 1,530 copies, 159 pages/

/Text/ In the book the principles of neutron methods of the continuous analysis of the composition of matter are set forth, the principles of the construction and the features of various types of neutron analyzers are examined. Particular attention is devoted to the theoretical and physicotechnical principles of the continuous activation analysis of matter in a stream as one of the new and very promising methods of automatic production control. The characteristics of various types of neutron sources, as well as of detectors and recording equipment, which are used in neutron analyzers, are examined in detail. Examples of the use of neutron methods for the continuous analysis of industrial products or the analysis of substances without taking samples under field conditions are cited. The neutron methods and equipment for the continuous analysis of matter, which were developed both by the authors of the book and under their guidance and by other authors in the USSR and abroad, are described in the book.

89 figures; 24 tables; 157 references.

Contents Page

Introduction

The increase of labor productivity in industry largely depends on the level of automation of production processes. Continuous processes can be automated easiest of all. In this case the control of such automated processes can be accomplished from a single control center by means of control computers. As a result of the monitoring of technological processes and the possibility of maintaining the optimum production schedule the utilization

of technological equipment increases considerably and products of better quality are produced. The automation of technological processes improves working conditions and reduces to a minimum the number of people working directly under harmful conditions.

One of the important conditions, without which the automation of technological processes is virtually impossible, is the need for the automatic or semi-automatic monitoring of the course of the process. Without exaggeration it can be stated: monitoring is the main link of all automatic production equipment. Merely by knowing the level, density, moisture content, thickness, chemical content or any other parameters essential for the process, it is possible to control this process.

For many years now radiation instruments have been used as sensitive elements (sensors) in many production processes. Much experience in developing and using automatic industrial equipment on the basis of these instruments has been gained in the USSR and many other countries. By means of primary radiation converters in many cases it is possible to determine the technological parameters without contact, which favorably distinguishes these sensitive elements from others which require contact with the medium being monitored. This advantage is particularly important in the automation of many processes in metallurgy, chemistry and several other sectors of industry.

In order to control many processes it is necessary to know the chemical composition of the mediums being monitored. Here continuous high speed processes require also the use of continuous methods of analysis. Numerous automatic analyzers of composition, including radiation analyzers, have been developed and are being used in practice.

However, there are no and, apparently, never will be any universal methods and instruments, which are capable of meeting all the diversity of demands made on them by various sectors of industry and various technological processes. Therefore, at present the study of new methods of continuous analysis is being continued, the development of instruments with the use of the latest achievements of science and technology is being carried out.

Experience shows that at enterprises of nonferrous metallury approximately half of all the analyses made at the central plant and shop laboratories are necessary for use in regulating technological processes. Usually the majority of these analyses are still made by the traditional "wet" chemical methods. Only slightly more than 10 percent of all the analyses are made in the laboratories by instrument methods. But even these methods for the most part require the taking, and then some preparation of the samples (weighing, dissolving, placement in an ampoule and so on). The increase of the accuracy of the analysis in many instances is checked by the imperfection of the methods and systems of sampling. Often the error of sampling is much higher than the error of the analysis itself.

Continuous analysis, in addition to the possibility of using its readings for controlling the course of technological processes, has a number of other

advantages over the ordinary laboratory methods of analysis with the taking of samples: 1) as a consequence of the increase of the amount of material being analyzed the representativeness of the results of the analysis increases and the error of sampling decreases; 2) the subjective errors of the analysts are eliminated; 3) the possibility of contactless continuous analysis, including through the walls of pipes and technological vessels, arises; 4) it is possible to make an analysis of the rock and ores in a natural bed; 5) the passivity of service personnel in the use of the results of the analysis for controlling the processes is eliminated.

The methods of continuous analysis, which are now being developed, for the most part are based on the further development of ordinary laboratory methods of analysis: titration, polarography, flame photometry and so forth.

In recent years much interest has been show for neutron methods of the continuous analysis of matter and the automatic monitoring of other technological parameters. Intensive research and development of automatic neutron analyzers of composition are being performed in the USSR, the United States, England, Canada and several other countries. The number of publications devoted to these problems is increasing like an avalanche. The analysis of patent materials shows a slightly different picture: some main patents and authorship certificates, in which the means and general diagrams of devices of the continuous analysis of composition are set forth, were submitted comparatively long ago (1955-1960), while in the technical patent materials of recent years only a few special questions of methods and the improvement of some assemblies of known devices are developed.

There are a large number of sectors of industry and industrial objects, at which it is expedient to use neutron methods of continuous analysis: the monitoring of the processes of extracting valuable components in the mining and metallurgical industry, the monitoring of the parameters of some intermediate products (for example, monitoring of the moisture content of agglomerate in ferrous metallurgy, determination of the protein in albumin products), the monitoring of some special processes (determination of the content of boron and the products of fission of nuclear fuel in the stream of coolant at nuclear electric power stations), monitoring of sewage for various contaminants (fluorine, uranium, mercury and so forth), the determination of the impurities in petroleum products. The problems of analyzing the rock and ores in a natural bed on the surface of the earth, in mine drifts, at the bottom of seas and oceans and on the surface of other planets are a special group of tasks. The methods of determining the consumption and rate of movement of liquid and bulk products, which can also be solved by means of neutron methods, border on analytic methods.

The mere enumeration of examples of the possible use of neutron methods of continuous analysis and monitoring shows their great promise. However, so far, not counting several short surveys /1-3/, not one work has been published which systematizes and summarizes the achievements in this field. The authors have taken the liberty to fill this gap.

It is necessary to note that questions of the theory and practice of neutron methods of logging bore holes have been omitted from this work. Logging according to the methods of accomplishment, the equipment and the means of interpretation of the results in many respects differs from other methods of continuous analysis. Moreover, neutron logging was proposed several decades ago; the research devoted to this method is set forth in much patent, scientific and technical literature and was generalized in several monographs.

The various methods and equipment are examined in the book with a varying degree of detail, which was caused in some cases by the lack of available information and in other cases by the varying level of elaboration of the problem. The research performed by the authors is covered somewhat more extensively in the book. Sections 5.3, 5.4 and 5.5 of Chapter 5 were written with the participation of V. L. Chulkin.

The authors realize that in this work, which is being undertaken for the first time, some shortcomings or inaccuracies might be encountered. The authors will gratefully accept critical remarks and suggestions.

In conclusion the authors take the opportunity to express their gratitude to N. D. Tyufyakov, V. L. Chulkin, N. Yu. Markun and S. V. Shagov for participating in the performance of the experiments and the useful advice given in the discussion of the manuscript of the book. The authors are also grateful to B. V. Ivlev and L. A. Pronina for much assistance in putting the manuscript into order.

7807
CSO: 1870

PUBLICATIONS

UDC 539.9.082:533.924

PARTICLES IN PLASMA RESEARCH

Moscow VZAIMODEYSTVIYE CHASTITS S VESHCHESTVOM V PLAZMENNYKH ISSEDOVANIYAKH (The Interaction of Particles With Matter in Plasma Studies) in Russian 1978 signed to press 17 Jan 78 pp 2-4, 271-272

/Annotation, table of contents and preface from book by Yuriy Vladimirovich Gott, Atomizdat, 2,550 copies, 272 pages/

/Text/ The available theoretical and experimental data on the losses of energy, scattering and ranges of ions of nonrelativistic energies in solid (amorphous) and gaseous substances are generalized and systematized in the book. Questions of the radiation damage to the first wall of a thermonuclear reactor under the effect of neutrons and charged particles are examined. The results of the practical application of the events, which occur in the interaction of particles with a solid, for the corpuscular diagnostics of laboratory and space plasma are cited.

The book is intended for specialists working in the field of plasma physics and nuclear physics and for students of VUZ's of the corresponding specialties.

34 tables, 381 figures, 583 references.

Contents

Preface

In recent years the interest in the events which accompany the interaction of particles (atoms, molecules, ions, electrons, neutrons) with a solid

has steadily increased. These questions are assuming particularly great importance in connection with the hopes for the development in the future of a controlled thermonuclear reactor (UTR). In an UTR the first, vacuum wall of the chamber will be subjected to the effect of large streams of various types of radiations. The interaction of the radiations with the materials of the wall leads to a change of the physical and mechanical properties of the latter and to the contamination of the plasma by the materials of the wall.

The effects occurring with the interaction of particles with solid matter and plasma are widely used in the corpuscular diagnostics of laboratory and space plasma.

Of course, this entire wide range of questions is difficult to set forth in a single book. Therefore, the author strove to cover in detail the results of theoretical and experimental research on the losses of energy, scattering and ranges of heavy (with a mass many times greater than the mass of an electron) particles in a solid (Chapters 1-6). The second part of the book (Chapters 7, 8) is devoted to an account of the practical application of these pehnomena in plasma physics.

Unfortunately, in spite of the fact that the study of the passing of particles through matter has been engaged in now for more than 70 years (the scattering of α-particles in matter was discovered in 1906, the subsequent classical studies of Geiger, Marsden and Rutherford led to the discover in 1911 of the nucleus.of the atom), our knowledge is still quite modest. Since no one has yet proposed to make the walls of an UTR out of monocrystalline materials, the interaction of particles only with amorphous substances is examined in the book.

In speaking about the energies of interacting particles, we will use the following terminology: particles of small energies are particles, the velocity of which is less than the velocity of any electron in an atom of the target, the velocity of particles of great energy exceeds the velocity of any electron of an atom of the target. All the remaining particles have intermediate energies. When examining these questions we will confine ourselves to the domain of nonrelativistic velocities.

Everywhere that it was possible empirical and approximate terms were used. The physical values are designated by symbols which nearly do not differ from the original works used by the authors. Therefore, often the same letter designates different physical values (for example, ρ is a parameter of aiming, the density of the substance, $\bar{\rho}$ is the average range expressed in dimensionless units, $\bar{\rho}_{np}$ is the average projective range). In studying the materials set forth in the book, the reader will probably understand these symbols without difficulty.

The author considers it his pleasant duty to express deep gratitude for the useful considerations, discussions and advice to M. S. Ioffe, B. I. Kanayev,

R. A. Kovrazhkin, R. I. Sobolev, V. G. Tel'kovskiy, V. V. Temnyy, O. B. Firsov, Ye. Ye. Yushmanov and Yu. N. Yavlinskiy.

7807
CSO: 1870

PUBLICATIONS

UDC 621.373.826

HOLOGRAPHIC METHODS, EQUIPMENT

Moscow OPTICHESKAYA GOLOGRAFIYA: PRAKTICHESKIYE PRIMENENIYA (Optical Holography: Practical Applications) in Russian 1978 signed to press 28 Jun 78 pp 2-4, 237-238

/Annotation, table of contents and introduction from book by Ye. A. Antonov, V. M. Ginzburg, Ye. N. Lekhtsiyer, E. V. Moroz, E. G. Semenov, B. M. Stepanov, N. S. Khanin, V. Ya. Tsarfin, Izdatel'stvo "Sovetskoye radio", 19,000 copies, 238 pages/.

/Text/ The experience of using new holographic methods and equipment (see "Gologrnfiya. Metody i apparatura" /Holography. Methods and Equipment/, edited by V. M. Ginzburg and B. M. Stepanov, Moscow, "Sovetskoye radio", 1974) for the solution of practical problems in various fields of physics, technology, biology, medicine and fine arts is generalized in the book.

The new results of a number of holographic studies are cited, including the studies of: optical self-focusing fibers, which are used for telecommunications; blood cells under cryogenic conditions; high speed processes (explosions, the combustion of condensed substances, gas-discharge plasma, the atomization of fuel by injectors, gas dynamic streams in the T-shape pipe joints of the intake-exhaust systems of motor vehicle diesel engines and others); the deformation of the images of murals depending on climatic conditions and others.

Metrological problems of holography are examined. Methods of nondestructive testing of industrial items are given. The MGI-1 holographic microscope, which has been series-produced since 1976, as well as devices for obtaining round and multi-angle holograms and holographic interferograms and their use are described.

The book is intended for specialists working in the field of holography and its use in various fields of science and technology.

23 tables; 135 diagrams; 155 references

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Introduction

At present holographic methods are being widely used in solving practical problems and in scientific research. Holography is being used in studies of high speed processes (explosions, combustion, gas-discharge plasma and so forth); for measuring deformations which occur in an item under the influence of various factors; for nondestructive testing of quality; for detecting internal defects of items (in introscopy); in studies of living cells and microorganisms, the process of the growth of plants; for obtaining three-dimensional images of the internal organs of man and animals; in operations on the restoration and determination of the optimum storage conditions of masterpieces of painting and others.

The methods and domestic equipment, which make it possible to perform holographic research in the optical and ultra-high frequency bands of waves, are described in the book "Gologrefiya. Metody i apparatura" /Holography. Methods and Equipment/ (edited by V. M. Ginzburg and B. M. Stepanov, Moscow, "Sovetskoye radio", 1974). These methods and equipment, as well as the methods and equipment, which were developed later and are presented in this book, are being used in the Soviet Union and abroad for research in the field of physics, medicine and technology. The results of the basic research were published in the periodic press during 1974-1977. At the same time, until recently there have been no systematized account of the practical aspects of holography, a description of the methods and their use and a generalization of the experience of the practical use of holography in solving specific problems of the national economy.

With this book the authors have attempted to fill this gap: to systematize and generalize the experience of using the developed methods and means of holography for solving problems in a number of fields of science and technology.

Taking into account the broad interest in holography and its practical use on the part of readers of various specialties, the authors give a brief

account (Chapter 1) of the basic data on the methods and schemes of holography, reference data on holographic equipment and radiation sources, questions of the metrological guarantee of the measures and some other information which is necessary for work with holographic devices.

A description of new holographic instruments and devices: the MGI-1 holographic microscope, round and multi-angle systems which make it possible to enlarge the field of use of holographic methods of measurements and nondestructive testing, is given in separate chapters.

In the book the main directions, methods and practical questions, which are connected with the use of holography for the nondestructive testing and measurements of various items and processes, are set forth using specific practical problems as examples. Topographical methods of nondestructive testing of the form of reflecting and transparent objects (including the immersion method of testing the form of reflecting items, which is at the basis of the draft standard of holographic measurements); the method of comparing the surfaces of a complicated form with standard items are examined; the results of the use of holography and laser interferometry for the nondestructive testing of deformations which occur in reflecting objects under the influence of environmental factors are cited.

Studies of the deformations of the images of the murals in the cathedrals of the Moscow Kremlin subject to climatic conditions for the purpose of determining the optimum temperature and moisture conditions, which ensure the safekeeping of the monumental painting on the walls of the cathedrals; the contactless testing of the topography of the surface of magnetic discs, which are used in storage systems; the use of holographic microscopy for the nondestructive testing of quality and measurement of the distribution of the index of refraction in optical fibers; the use of holographic microscopy for studying the vitality of cells, particularly blood cells under cryogenic conditions, are described.

The distribution of the concentration of the solution in the process of the growth of crystals is studied. An explanation of the previously observed phenomenon of the stratification of the solution when growth crystals of KDR in a static mode was found on the basis of this research. The results of the study of the uniformity of artificially growth crystals by the method of holographic interferometry are cited.

The application of holography for the study and measurement of the parameters of multicomponent rapidly changing systems, which contain a liquid, solid and gaseous phase and a plasma, is examined, the main characteristics are cited and the problems of studying such systems are specified.

A number of practical examples of the use of pulse holography for the calculation of the density of currents, the distribution of velocities in an overflow stream, the study of the process of combustion of condensed systems, the analysis of the distribution of charged and neutralized particles in plasma are given. The process of the atomization of fuel by injectors

and the characteristics of the gas dynamic streams in the intake-exhaust systems of motor vehicle diesel engines are studied.

The book was written by a collective of authors under the general editorship of V. M. Ginzburg and B. M. Stepanov. The following people worked on the book: Ye. A. Antonov (§ 1.1, 1.2), V. Ya. Tsarfin (§ 1.3, 1.4, Chapter 6), E. G. Semenov (§ 1.5, Chapter 2), V. M. Ginzburg (Chapters 2-7, § 1.3), B. M. Stepanov (Chapters 2-6, § 1.3), Ye. N. Lekhtsiyer (Chapters 3-5), E. V. Moroz and N. S. Khanin (Chapter 7).

The authors hope that the book will be useful for specialists who work in various fields of science and technology and who use holographic methods for solving practical problems and in scientific research.

The authors are extremely thankful to the reviewers of the book: Corresponding Member of the USSR Academy of Sciences Doctor of Technical Sciences L. D. Bakhrakh and Doctor of Physicomathematical Sciences Yu. A. Bykovskiy, for a number of valuable suggestions which were taken into account when correcting the book.

The authors express gratitude to Ya. A. Gabelev for much assistance in the preparation and editing of the manuscript of the book.

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CSO: 1870

PUBLICATIONS

UDC 533.9.13

PROPERTIES OF NEGATIVE IONS AND ASSOCIATED PROCESSES

Moscow OTRITSATEL'NYYE IONY (Negative Ions) in Russian 1978 signed to press 11 May 78 pp 2-4, 176

/Annotation, table of contents and preface from book by Boris Mikhaylovich Smirnov, Atomizdat, 1,830 copies, 176 pages/

/Text/ Information, which pertains to the properties of negative ions and the processes which take place with their participation, is presented. The methods of determining the energy of the affinity of electrons to the atom and the molecule are analyzed and the present values for these magnitudes, as well as for the energies of dissociation of molecular negative ions and the parameters of auto-ionized states of ions, which are formed in the process of collision of electrons with molecules, are cited. The processes of the formation of ions in paired and triple collisions of electrons with molecules, as well as the processes of the recombination of positive and negative ions in paired and triple collisions are studied. The processes of the photoejection of an electron from a negative ion, the photodissociation of a molecular negative ion, as well as the photo-attachment of an electron to an atom or a molecule are examined.

The book contains much reference material. It is intended for specialists working in the field of the physics and chemistry of plasma, atomic and molecular physics, as well as in related fields, who need information on the properties of charged particles and the elementary processes taking place with their participation.

49 figures, 40 tables, 698 references.

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Preface

Negative ions play an important role in weakly ionized gas. The transfer of the negative charge from the electron to the negative ion leads to a sharp decrease of the conductivity of plasma and changes the rate of the recombination in it of the positive and negative charges. The process of

the photo-attachment of an electron to an atom influences the radiating properties of a weakly ionized gas. Thus, the formation of negative ions of hydrogen in the photosphere of the sun with the photo-attachment of an electron to an atom of hydrogen determines the radiation of the sun in the optical portion of the spectrum. The luminescence of the night sky to a great extent is connected with the photo-attachment of an electron to an atom of oxygen. Negative ions play an important role in the upper atmosphere of the earth, where at an altitude of up to 100 km the negative charge of the atmosphere is connected with negative ions, and the main type of negative ions depends on the altitude and the time of day. The list of examples demonstrating the role of negative ions could be continued, and their number is increasing with the development of applied science in recent times, mainly in connection with the development of capacitive gas lasers, gas-discharge instruments and plasma chemistry. All this creates the need for information about negative ions.

The goal of this book is to present information on negative ions and the elementary processes in which they participate. At the basis of the book is the material of the previous books of the author on this theme ("Atomnyye stolknoveniya i elementarnyye protsessy v plazme" /Atomic Collisions and Elementary Processes in Plasma/, Moscow, Atomizdat, 1968; "Iony i vozbuzhdennyye atomy v plazme" /Ions and Excited Atoms in Plasma/, Moscow, Atomizdat, 1974). This book has retained the direction of the preceding books, the nature and manner of exposition, and for those questions, in which no new information appeared, the materials of the preceding books were used in it.

Along with this a large number of problems were subject to serious treatment. There are directions in which in recent years fundamentally new results have been obtained. For example, a new method of measuring the energy of affinity of an electron to an atom and a molecule, which was developed several years ago and is based on the study of the photodecay of negative ions upon the intersection of a beam of negative ions with the beam of an adjustable laser, made it possible to obtain a wealth of information on the energy of affinity of electrons to an atom and a molecule with a previously inaccessible accuracy. Modern methods made it possible to determine the parameters of auto-ionized states for a number of molecular negative ions. These states are formed in the process of the elastic and inelastic scattering of an electron on a molecule and therefore contain information on the collision of the electron with the molecule. In recent years measurements of the sections of photodissociation for negative ions were made, which previously were entirely lacking. For many problems new information has been obtained, which is extending our notions about the topic and, of course, is also included in the book.

In foreign literature there are a large number of surveys and monographs on negative ions. The most complete one is the monograph of H. Massey, which has run three editions (H. S. W. Massey, "Negative Ions," Cambridge University Press, 1976).

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